Cambridge Pre-U

Cambridge International Examinations
Cambridge Pre-U Certificate

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

5415230159

BIOLOGY (PRINCIPAL) **9790/01**

Paper 1 Structured **May/June 2017**

2 hours 30 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Section A
Answer **all** questions.
Write your answers in the spaces provided on the Question Paper.

Section B
Answer **all** questions.
Write your answers in the spaces provided on the Question Paper.

Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
Section A	
21	
22	
23	
24	
25	
26	
Total	

The syllabus is approved for use in England, Wales and Northern Ireland as a Cambridge International Level 3 Pre-U Certificate.

This document consists of **30** printed pages and **2** blank pages.

CAMBRIDGE International Examinations

[Turn over

Section A

Answer **all** questions.

You are advised to spend no more than 30 minutes on this section.

1 Which statement describes the term *activation energy* for an enzyme-catalysed reaction?

A the energy required for an enzyme-substrate complex to form

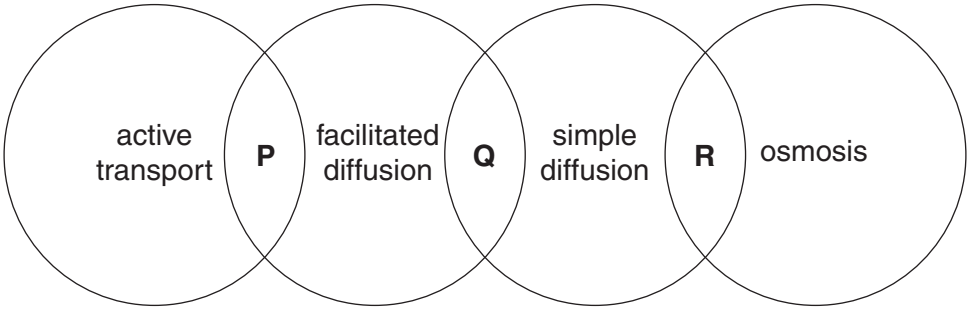
B the energy that is released during an enzyme-catalysed reaction

C the energy that is required for an enzyme to reach V_{max}

D the energy that must be gained for a particular reaction to take place

answer .....[1]

2 Four mechanisms involved in the movement of substances across membranes are shown below.



Which features of these transport mechanisms are represented by **P**, **Q** and **R**?

	P	Q	R
A	involves membrane carrier proteins	passive movement	movement against a concentration gradient
B	involves membrane transport proteins	movement down a concentration gradient	passive movement
C	movement against a concentration gradient	involves membrane channel proteins	movement through the hydrophobic core of the phospholipid bilayer
D	requires energy supplied by ATP	movement through the hydrophobic core of the phospholipid bilayer	involves membrane channel proteins

answer .....[1]

3 In dividing human cells, faults can occur in the mechanisms that maintain telomeres.

When viewed at the metaphase stage of mitosis, which feature would appear different in dividing cells with these faults compared with dividing cells that do not have these faults?

A length of chromosomes

B number of centrioles

C shape of spindle

D size of centromeres

answer .....[1]

4 For what is the Lincoln Index used?

A to calculate species density in a defined area

B to determine the biodiversity of an ecosystem

C to estimate population size using mark-release-recapture

D to measure species distribution along a transect

answer .....[1]

5 The fusion of two different cell types is one step in the sequence of events resulting in the commercial production of monoclonal antibodies.

Which two cell types are fused?

A hybridoma and myeloma

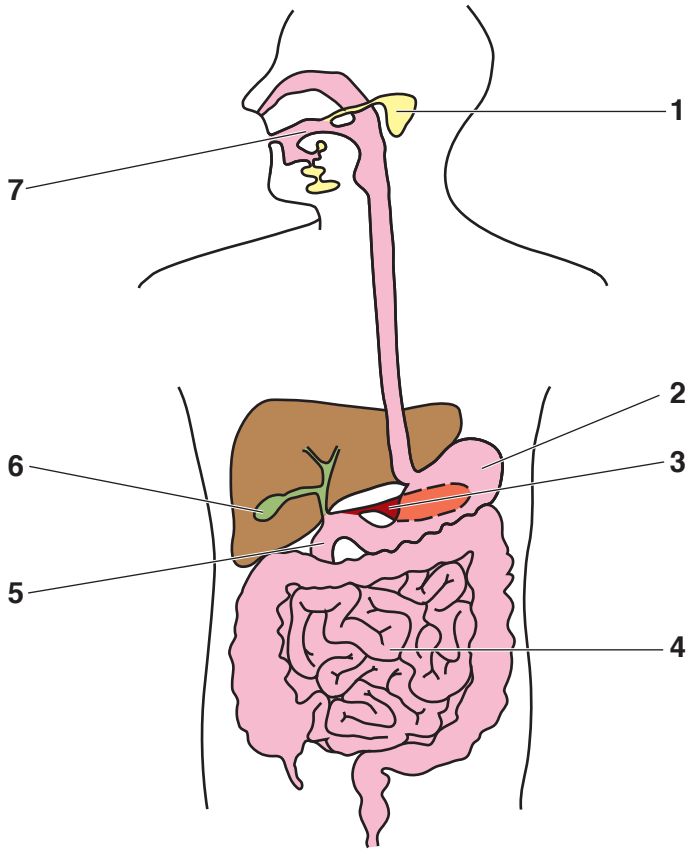
B plasma cell and hybridoma

C plasma cell and myeloma

D T lymphocyte and myeloma

answer .....[1]

6 The figure below is a diagram of the human alimentary canal.



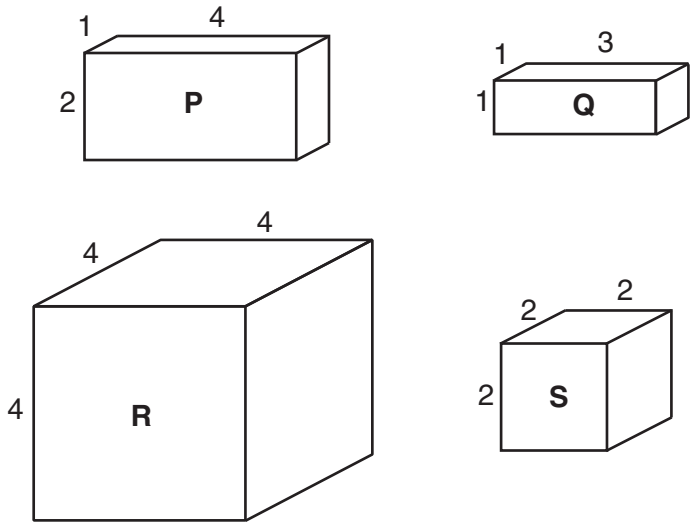
Which column, **A**, **B**, **C** or **D**, lists correct functions for structures **1–7**?

	A	**B**	**C**	**D**
1	amylase acts on starch	amylase acts on starch	produces carbohydrase	produces carbohydrase
2	produces hydrochloric acid	activation of pepsinogen	activation of pepsinogen	produces hydrochloric acid
3	produces sodium hydrogencarbonate	produces amylase	produces lipase	produces maltase
4	produces maltase	trypsinogen converted to trypsin	absorption of vitamin B_{12}	absorption of cholesterol
5	produces exopeptidases	produces trypsinogen	produces maltase	produces trypsinogen
6	produces bile	produces bile	stores bile	stores bile
7	lipase begins digestion of lipids	produces sodium hydrogencarbonate	amylase acts on starch	amylase acts on starch

answer .....[1]

7 An investigation was carried out into the effect of surface area to volume ratio on diffusion.

A block of agar containing sodium hydroxide solution and Universal Indicator solution was cut into four smaller blocks of different sizes, as shown in the diagram below. All dimensions are in centimetres.



The blocks were placed in a solution of 0.1 mol dm^{-3} hydrochloric acid. As the hydrochloric acid diffused into each block, a colour change was observed. The time taken for each block to change its colour completely was recorded.

Statements **A**, **B**, **C** and **D** are some predictions and explanations given by a student before carrying out the investigation.

Which of these statements is correct?

A Although **P** and **S** have equal volumes, it will take less time for **S** to change colour completely.

B **P** will take less time than **Q** to change colour completely, as **P** has proportionately more surface area for each unit of volume.

C The length, width and breadth of **R** are double that of **S**. Compared to **S**, this halves the surface area to volume ratio and increases the time taken for **R** to change colour completely.

D The two blocks with the lowest surface areas will take longer to change colour completely than the two blocks with the highest surface areas.

answer .....[1]

8 Which statement does **not** describe a phenetic approach to classification?

A It groups organisms based on a numerical assessment of their observable features.

B It groups organisms based on one or more features shared with a common ancestor.

C It quantifies the overall morphological similarity of the organisms being classified.

D It is often used where no comparative molecular biology data are available.

answer .....[1]

9 In the initiation and control of heart action, which role is performed by the atrioventricular node (AVN)?

A To act as non-conducting tissue so that the atrial and ventricular walls do not contract at the same time.

B To act as conducting tissue and pass impulses towards the Purkyne fibres to initiate ventricular systole.

C To send out a wave of excitation across the walls of the atria to cause atrial systole.

D To send out a wave of excitation from the heart apex so that the ventricles contract from the base up.

answer .....[1]

10 Which statements describe the organic base adenine?

1 component of DNA, RNA and ATP

2 purine

3 pyrimidine

4 single ring structure

5 double ring structure

A 2 and 4

B 3 and 5

C 1, 2 and 5

D 1, 3 and 4

answer .....[1]

11 Which statements concerning the circulatory systems of amphibians, fish and mammals are correct?

1 Fish have a three-chambered heart, whereas mammals have a four-chambered heart.

2 In the fish circulatory system, blood is oxygenated in the gills and returns to the heart before being pumped to the rest of the body.

3 In the amphibian circulatory system, the heart consists of two atria and only one ventricle.

4 In the mammalian circulatory system, blood from the pulmonary circulation enters the right atrium of the heart.

5 The amphibian circulatory system and the mammalian circulatory system are double circulatory systems.

A 1 and 3

B 1 and 4

C 2 and 4

D 3 and 5

answer .....[1]

12 Which observations describe the autoimmune response shown in myasthenia gravis?

1 Antibodies, produced by specific B lymphocytes, cause damage to muscle cells.

2 Cytotoxic (killer) T lymphocytes produce a chemical to punch holes in muscle cells.

3 Macrophages fail to distinguish between self and non-self antigens and engulf muscle cells.

4 Receptors on muscle cells are not recognised as self-antigens and are destroyed by an immune response.

5 Helper T cells that produce cytokines to stimulate neutrophil action are not destroyed by the immune system.

A 1 and 4

B 2 and 4

C 3 only

D 2, 3 and 5

answer .....[1]

13 Which statements support the theory that eukaryotes originated through endosymbiosis?

1 The smallest eukaryotic cells are the same size as many bacteria.

2 Eukaryotic cells and prokaryotic cells both have ribosomes free in the cytoplasm.

3 Human mitochondrial DNA is circular and contains no introns.

4 Chloroplasts divide by binary fission, independently of the plant cell.

A 1 and 3 only

B 1 and 4

C 3 and 4

D 1, 2 and 3

answer .....[1]

14 Which are features of a molecule of sucrose?

1 can be hydrolysed to glucose and fructose

2 contains two glycosidic bonds

3 product of partial amylopectin digestion

4 cotransported with hydrogen ions into companion cells

A 1 only

B 1 and 4

C 2 and 3 only

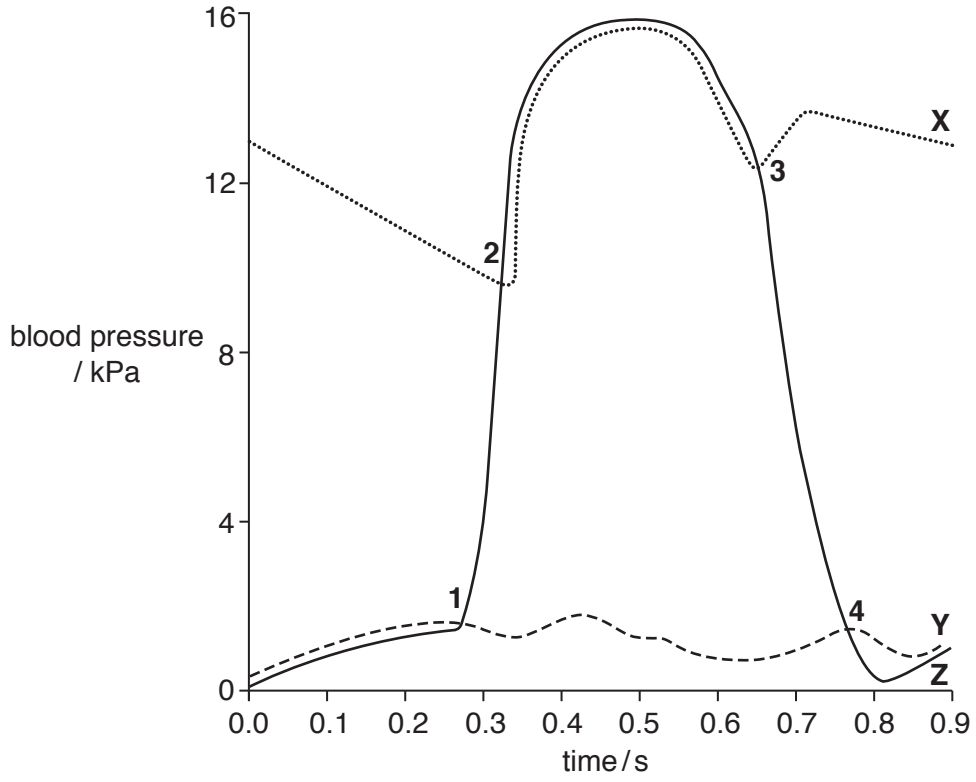
D 2, 3 and 4

answer .....[1]

Questions 15 and 16

Use the graph below to answer Questions **15** and **16**.

The graph shows the pressure changes that occur in the left side of the human heart during the cardiac cycle. Labels **1** to **4** indicate the points at which a valve opens or shuts.



15 Which structures are represented by the pressure curves **X**, **Y** and **Z** ?

	X	Y	Z
A	aorta	vena cava	left atrium
B	aorta	left atrium	left ventricle
C	left atrium	vena cava	left ventricle
D	left ventricle	left atrium	aorta

answer .....[1]

16 Which set of labels is correct?

A **1** and **3** = valves close and **2** and **4** = valves open

B **1** and **4** = valves close and **2** and **3** = valves open

C **1** = left atrioventricular (bicuspid) valve closes and **3** = semi-lunar valve opens

D **2** = left atrioventricular (bicuspid) valve opens and **3** = left atrioventricular (bicuspid) valve closes

answer .....[1]

Questions 17, 18, 19 and 20

For each of Questions **17**, **18**, **19** and **20**, name the protein that is being described.

17 It has an active site that binds to a six-carbon sugar phosphate and an allosteric site that binds to ATP. ATP acts as an inhibitor when the concentration of ATP is high.

answer .....[1]

18 It acts as a transcription blocking factor in dwarf rice. It is not removed by the ubiquitin / proteasome mechanism because of a mutation that results in a lack of gibberellin.

answer .....[1]

19 A globular protein that is able to bind calcium ions that have entered the sarcoplasm from the sarcoplasmic reticulum. Calcium binding to this protein leads to binding sites on actin filaments being exposed.

answer .....[1]

20 A glycoprotein secreted by the anterior pituitary gland into the bloodstream. In females, it has its site of action at the ovaries and one of its effects is to stimulate the production of oestrogen.

answer .....[1]

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Section B

Answer **all** questions.

You are advised to spend no more than 2 hours on this section.

21 The kidney is an organ that has an important role in homeostasis.

(a) Define homeostasis.

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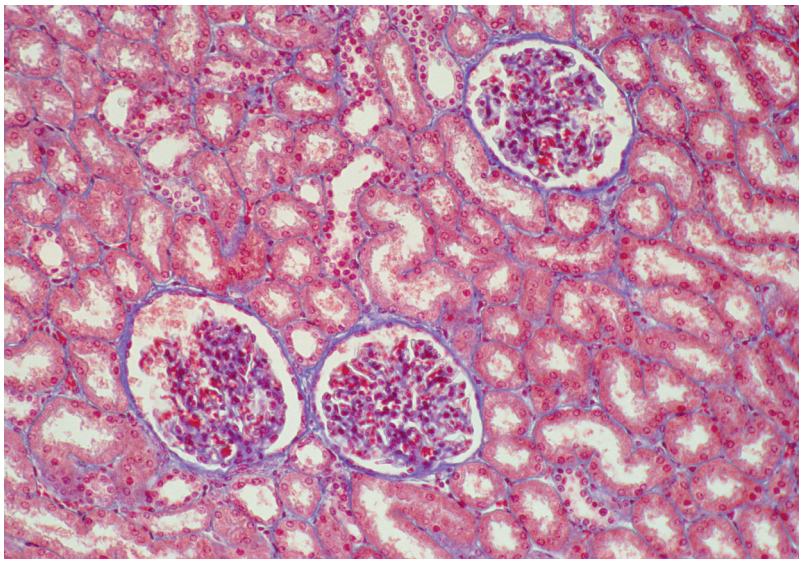
(b) Fig. 21.1 is a photomicrograph of a kidney section, showing renal (Bowman's) capsules surrounded by tubules.



×150

Fig. 21.1

(i) Name the area of the kidney from which this section was taken.

.....[1]

(ii) State the name given to the capillary network that is visible within each renal capsule in Fig. 21.1.

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(iii) Describe the differences between the blood entering and the blood leaving this capillary network in a renal capsule **and** explain why these differences exist.

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[Total: 8]

22 The manuka plant, *Leptospermum scoparium*, is a common native shrub of New Zealand and Australia. It is a popular garden plant in many parts of the world, with many varieties displaying different stem, leaf and flower colours.

Commercially, the manuka plant is important for two reasons. Bees turn nectar from the flowers into a high-quality honey. Oils can also be extracted from the leaves. Both the honey and the oils are thought to have medicinal properties. Different varieties of manuka plant can produce slightly different oils.

Fig. 22.1 shows the leaves and flowers of one variety of manuka plant, *L. scoparium nanum*.

Fig. 22.1

A number of studies of phenotypic and genotypic variation in *L. scoparium* have been carried out. Three investigations are outlined below.

Investigation 1
The dimensions of leaves taken from plants growing across the entire geographical range within New Zealand were measured. An analysis of the patterns of variation showed a correlation with both geographic location and the plant's habitat.

Investigation 2
Seeds from different populations of *L. scoparium* taken from different habitat types were grown to mature plants under uniform conditions. The leaf dimensions of the mature plants showed that:

- there was a range of measurements within each population
- plants from each population produced leaves with comparable dimensions to those in the original habitat.

Investigation 3
Seeds were collected from five plants of the same population growing within a small area. The seeds were sown in an experimental plot and grown to mature plants under identical conditions. Table 22.1 shows two of the phenotypic features recorded for ten of these mature plants.

Table 22.1

plant number	leaf dimension ratio (leaf length : leaf width)	leaf colour
1	3.3 : 1	olive green, copper tinge
2	3.2 : 1	clear green
3	2.8 : 1	clear, bright green
4	3.6 : 1	dull green
5	4.3 : 1	clear green, copper tinge
6	2.2 : 1	clear green
7	2.4 : 1	dull green
8	4.0 : 1	clear, bright green
9	3.2 : 1	clear green, yellow tinge
10	2.8 : 1	dull green, yellow tinge

(a) Discuss the extent to which results from **Investigations 1**, **2** and **3** show that:

- phenotypic variation in leaf dimension is due to a contribution of both genetic and environmental variation

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- phenotypic variation in leaf colour is an example of continuous variation.

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[5]

[Turn over

(b) Suggest advantages of maintaining the genetic diversity shown in *L. scoparium*.

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Manuka honey is known to have antibacterial properties and has been studied for its potential medicinal benefits. One area of interest is the effect of the honey against bacteria that have become resistant to antibiotics, such as strains of *Clostridium difficile*.

C. difficile is a Gram-positive anaerobe found in the soil. It can also live in the human gut, where it can become a pathogen.

(c) State the kingdom to which *C. difficile* belongs.

.....[1]

(d) Infection caused by the *C. difficile* pathogen is potentially life threatening.

Explain why penicillin is a suitable choice of antibiotic for treating an infection caused by a strain of *C. difficile* that is not resistant to antibiotics.

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.....[2]

An investigation was carried out into the antibacterial effect of manuka honey on two strains of *C. difficile*, **A** and **B**, both known to have antibiotic resistance.

- Six concentrations of manuka honey solution were prepared: 0%, 10%, 20%, 30%, 40% and 50%.
- Six agar plates, one for each concentration of manuka honey solution, were prepared.
- In each agar plate, four wells, each 5 mm in diameter, were cut out using a sterile cork borer.
- Each plate was inoculated by spreading *C. difficile* strain **A** across the whole surface.
- A constant volume of the relevant honey solution was then added to the wells.
- The same procedure was repeated with the second strain of *C. difficile,* strain **B**.
- The plates were incubated and the diameters of any zones of inhibition that formed were measured on day two.
- Incubation was continued for seven days.

Fig. 22.2(a) shows the appearance on day two of the agar plate with 0% manuka honey concentration for strain **A**.

Fig. 22.2(b) shows the appearance on day two of the agar plate with 50% manuka honey concentration for strain **A**.

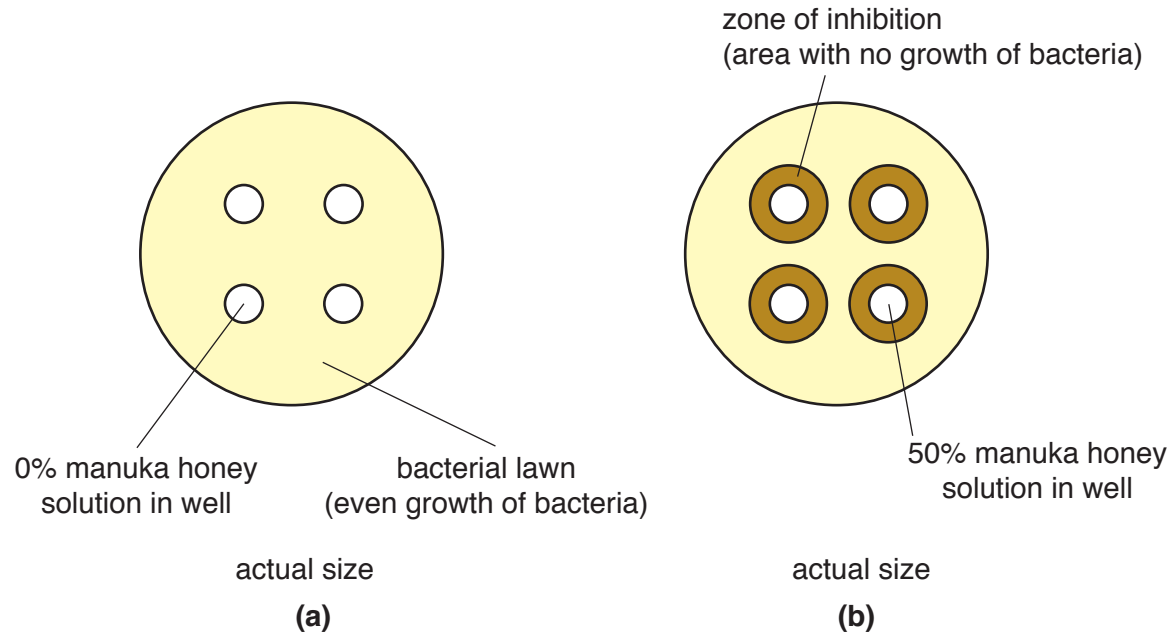

Fig. 22.2

(e) The method used in this investigation is termed an agar-diffusion method.

State what is meant by diffusion.

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Table 22.2 shows the mean diameters of the zones of inhibition on day two for each of the different concentrations of manuka honey solution, for both strain **A** and strain **B**.

Table 22.2

percentage concentration of manuka honey	strain **A** mean zone of inhibition (including diameter of well) / mm	strain **B** mean zone of inhibition (including diameter of well) / mm
0	5.0	5.0
10	5.0	5.0
20	5.0	9.1
30	8.4	9.3
40	9.5	10.2
50	10.2	10.4

(f) Describe **and** interpret the results shown in Table 22.2.

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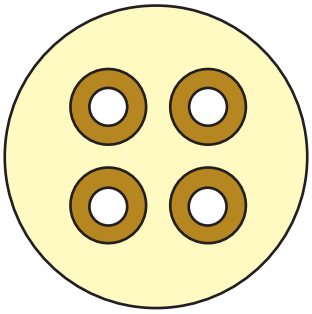
(g) After six days, manuka honey no longer has any antibacterial effects.

Fig. 22.3 shows the appearance on day seven of the agar plate with 50% manuka honey concentration for strain **A**.



actual size

Fig. 22.3

Suggest how the results shown in Fig. 22.3 confirm that manuka honey kills cells of *C. difficile* (bactericidal effect), rather than inhibits the growth of the cells (bacteriostatic effect).

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(h) Explain the cause **and** spread of genetic resistance to antibiotics in populations of bacteria.

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[Total: 20]

[Turn over

23 Some genetic conditions, such as severe combined immunodeficiency (SCID), can be treated using gene therapy with viral vectors, such as retroviruses. Viral vectors allow the therapeutic allele of a gene to be inserted into defective cells.

One method of gene therapy for SCID involves removing blood stem cells (haematopoietic stem cells) from a person with SCID, modifying them using a viral vector and then putting the cells back into the person.

(a) (i) Explain why stem cells are useful for gene therapy treatment.

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.....[1]

(ii) Other gene therapies deliver the therapeutic allele to target cells using viral vectors that are introduced directly into the body.

Suggest **one** method that can be used to introduce a viral vector directly into the body.

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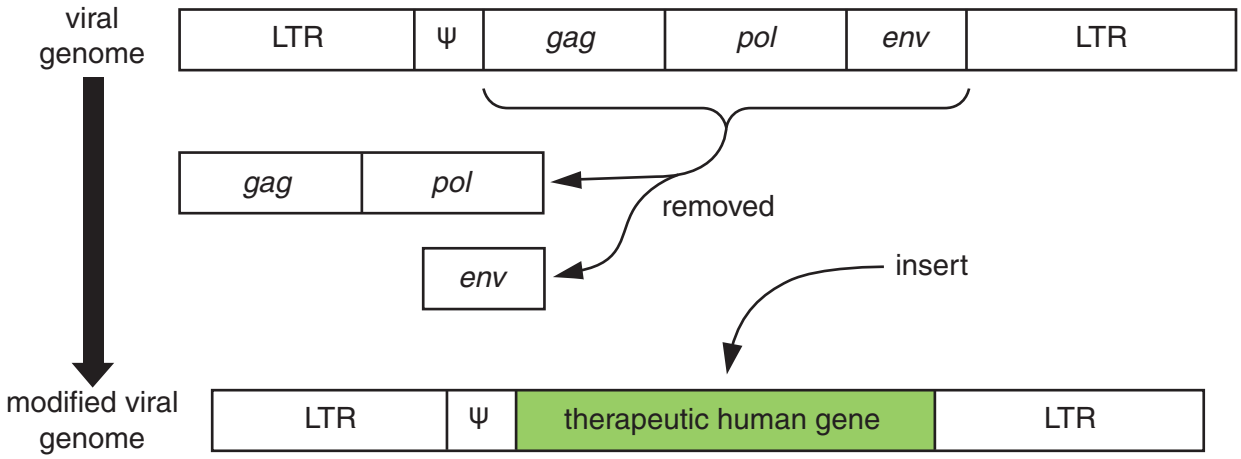
.....[1]

Retroviruses have RNA as their genetic material. This is enclosed by a protein coat made of many protein subunits and an outer envelope made of a phospholipid bilayer.

The production of viral vectors from retroviruses for use in gene therapy firstly requires modification of the viral genome, summarised in Fig. 23.1.



key:
LTR = regulatory and control sequences
Ψ = sequence for directing the correct packaging of the genome into the protein coat during viral assembly
gag = codes for structural proteins for the protein coat
pol = codes for polyprotein, which is cleaved after synthesis to form two enzymes: integrase and reverse transcriptase
env = codes for viral proteins added to the outer envelope of the virus

Fig. 23.1

To obtain the viral vectors, modified mammalian cells known as packaging cells are used. These are engineered to contain in their nucleus the modified viral genome and the removed genes *gag*, *pol* and *env.* The purpose of a packaging cell is to replicate the viral genome and to synthesise viral proteins.

The sequence of events occurring in a packaging cell is:
- replication of the viral genome
- expression of *gag*, *pol* and *env* genes to produce viral proteins
- assembly of viral vector
- budding of viral vector to exit the cell
  - using host cell surface membrane to form the viral envelope
  - adding env proteins to the viral envelope.

The production of these viral vectors is summarised in Fig. 23.2.

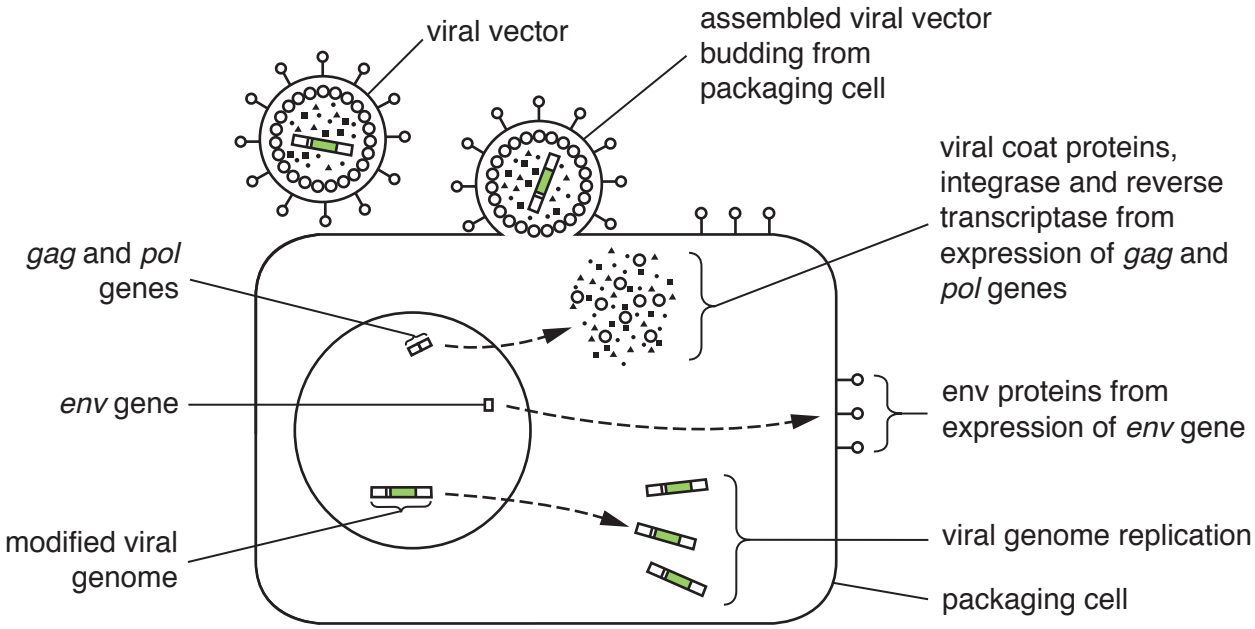


Fig. 23.2

Each viral vector produced contains integrase, reverse transcriptase and the modified viral genome. Env proteins are inserted into the envelope as the vector buds from the packaging cell.

(b) Suggest the name of the enzyme that is used for the synthesis of RNA in viral genome replication.

.....[1]

(c) Suggest **and** explain the functions of the env proteins located in the viral envelope in the gene therapy treatment.

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(d) Following the successful uptake of the viral vector into the target cell,

(i) outline the role of reverse transcriptase

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(ii) suggest the role of integrase.

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(e) Suggest why it is important that the viral vector lacks the *gag*, *pol* and *env* genes.

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(f) Outline the limitations of using viral vectors in gene therapy for SCID.

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SCID and a disease known as Wiskott-Aldrich syndrome are examples of rare disorders in which there is a defect in one or more aspects of the immune system. Collectively, such disorders are known as primary immunodeficiency diseases.

(g) In Wiskott-Aldrich syndrome, the functioning of B lymphocytes and T lymphocytes is defective and there is a low platelet count, with the size of platelets being smaller than normal.

Suggest **and** explain how Wiskott-Aldrich syndrome will affect a person who is not receiving treatment for the disease.

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(h) A study of six generations of one family led to the conclusion that the Wiskott-Aldrich syndrome showed sex-linked inheritance. More recent studies have located the gene on the X chromosome. The faulty allele is recessive.

Describe **and** explain the pattern of inheritance that would have been observed in the original family study.

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[Total: 19]

24 *Halobacterium salinarum* is a member of the Archaea. It is an aquatic, motile microorganism that respires aerobically and actively seeks out locations where oxygen is present.

(a) Archaea is a taxonomic grouping called a domain.

Name the other **two** domains.

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.....[1]

(b) Suggest which cell structure allows *H. salinarum* cells to be motile.

.....[1]

H. salinarum is described as an extreme halophile. This means it lives in water containing a far higher concentration of sodium chloride than normal seawater. It is able to synthesise four different types of membrane protein, which act as light-absorbing pigments:

- halorhodopsin
- sensory rhodopsin I
- sensory rhodopsin II
- bacteriorhodopsin.

Each of these pigments contains a non-protein prosthetic group called retinal. Retinal absorbs light energy to cause a conformational change in the membrane protein.

(c) Halorhodopsin pumps chloride ions into the cell. This is accompanied by the entry of sodium or potassium ions.

Explain why a non-halophile would not survive in the high-salt environment of extreme halophiles **and** suggest how the possession of halorhodopsin allows *H. salinarum* to survive in such conditions.

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(d) When oxygen and respiratory substrates are available, *H. salinarum* uses sensory rhodopsin II, which absorbs blue-green light, in order to move towards darker areas. This enables it to avoid damage from ultra-violet light from the sun.

Suggest how ultra-violet light can cause damage to *H. salinarum* cells.

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.....[1]

(e) When oxygen and respiratory substrates are unavailable, the organism produces sensory rhodopsin I and bacteriorhodopsin.

Sensory rhodopsin I absorbs red-orange light. This triggers a cell-signalling mechanism, which causes *H. salinarum* to move towards lighter areas for photosynthesis.

(i) Name the type of behaviour shown by *H. salinarum* that results in this movement towards lighter areas.

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(ii) With reference to the behaviour shown by *H. salinarum* to red-orange light, outline the principles of cell signalling.

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Bacteriorhodopsin absorbs light and uses this energy to pump protons out of the cell. This creates a proton gradient. A ribbon diagram of bacteriorhodopsin in the cell surface membrane is shown in Fig. 24.1.

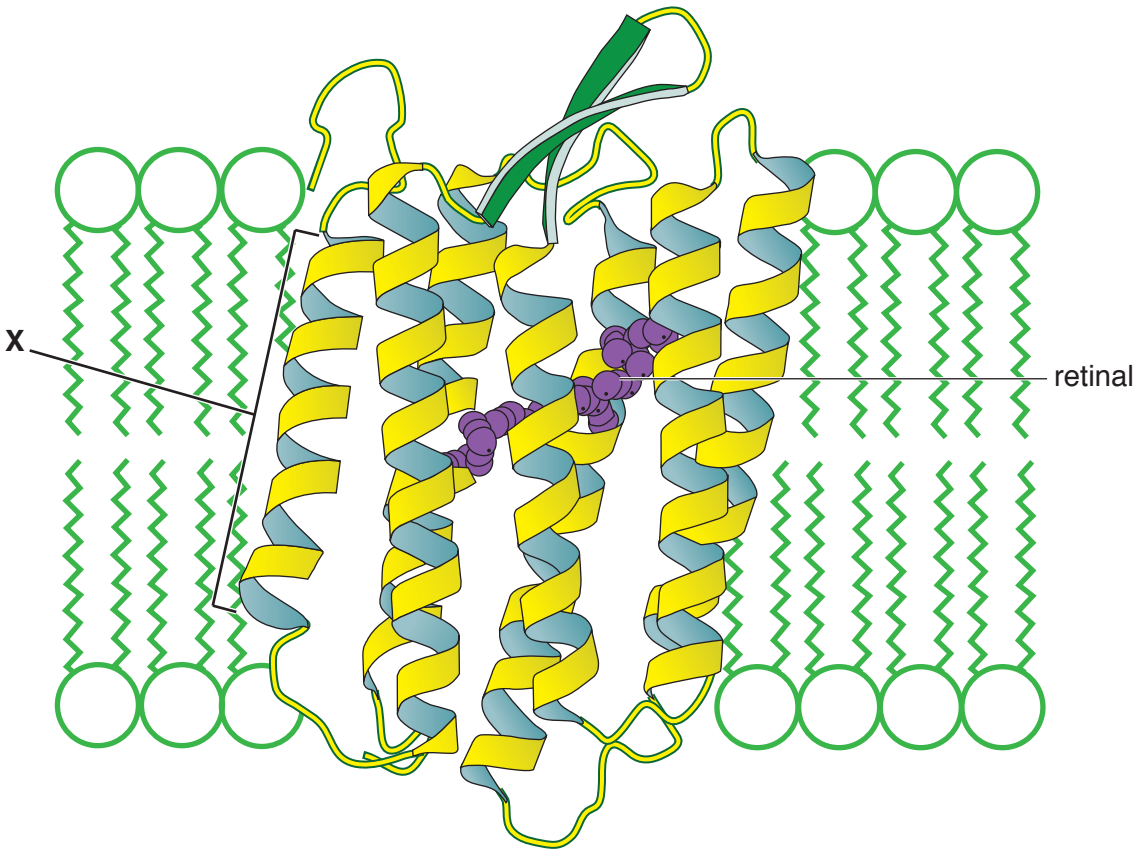

Fig. 24.1

(f) Describe the protein structure labelled **X**.

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(g) Bacteriorhodopsin has been used in two experiments to demonstrate the principles of chemiosmosis.

Two different types of artificial vesicles were synthesised.

In an initial experiment, vesicles were placed in a solution with a low hydrogen ion (H^+) concentration and exposed to light. Each vesicle consisted of a phospholipid bilayer that incorporated bacteriorhodopsin molecules. The results of this experiment showed that hydrogen ions (protons) were pumped into the vesicle from the solution.

A second experiment used artificial vesicles consisting of a phospholipid bilayer that incorporated bacteriorhodopsin molecules and the membrane enzyme complex that catalyses the formation of ATP from ADP and Pi (inorganic phosphate). ADP and Pi were added to the external solution. The results of this experiment showed that ATP was produced when the vesicles were exposed to light.

(i) Name the enzyme that catalyses the formation of ATP from ADP and Pi.

.....[1]

(ii) Fig. 24.2 summarises the second experiment.

Complete Fig. 24.2 by:

- adding an arrow head to each of the lines passing through the bacteriorhodopsin and the enzyme complex to show the direction of movement of protons during the experiment
- adding six protons to the diagram to represent the proton gradient formed during the experiment. Use the symbol H^+ to represent each proton.

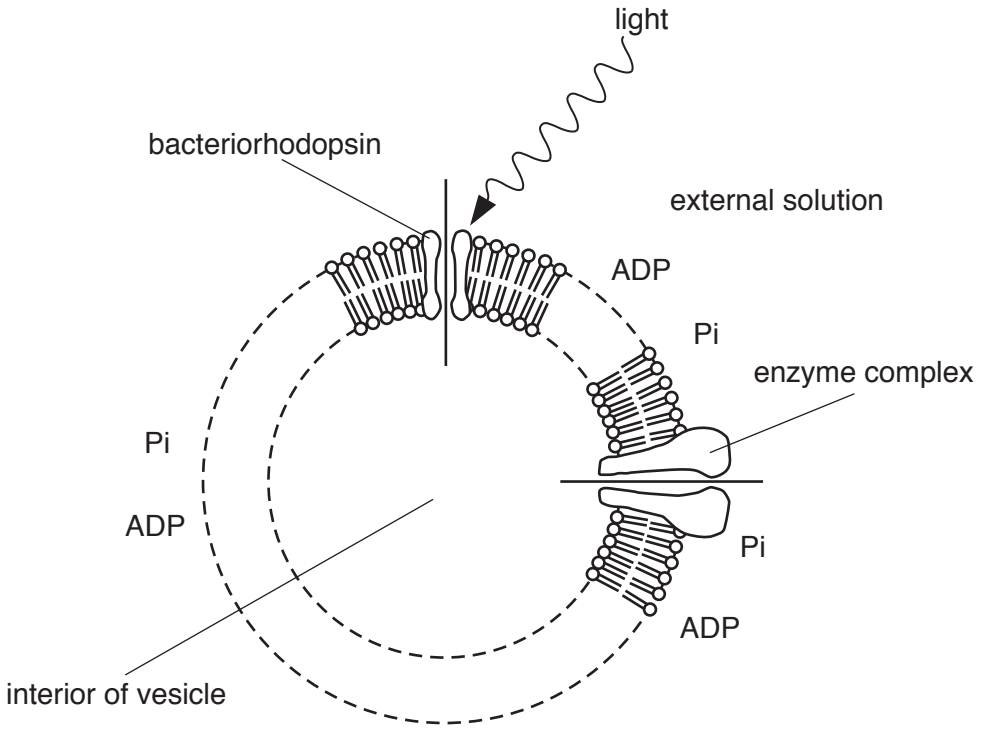

Fig. 24.2

[1]

(iii) Outline the differences between chemiosmosis within a mitochondrion of a respiring cell and the demonstration of chemiosmosis in the second experiment described.

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.....[4]

[Total: 20]

25 Table 25.1 shows examples of crop plants grown in the UK.

Table 25.1

C3 crop plant examples		C4 crop plant examples	
name	species name	name	species name
barley	*Hordeum vulgare*	maize	*Zea mays*
oat	*Avena sativa*	millet	*Panicum miliaceum*
common wheat	*Triticum aestivum*	miscanthus	*Miscanthus sinensis*
sugar beet	*Beta vulgaris*	sorghum	*Sorghum bicolor*

In the UK the three most common crop plants, in terms of yield, are wheat, barley and oats. The C4 crop plants are considered minor crop plants.

The relative importance of C3 and C4 crop plants varies in different parts of the world.

(a) Explain the global distribution of C3 and C4 plants and discuss the potential impact of climate change on future patterns of agriculture.

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[Turn over

(b) Fig. 25.1 shows flowers of oilseed rape, *Brassica napus*, which is a crop plant.

B. napus can be pollinated by honeybees.

Fig. 25.1

Many other flowering plants also transfer their male gametes by insect pollination.

Describe ways in which flowering plants, such as *B. napus*, are adapted for insect pollination.

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[Total: 9]

26 Guard cells can carry out cyclic and non-cyclic photophosphorylation.

(a) Table 26.1 summarises events occurring in non-cyclic photophosphorylation. The statements are not in sequence and are incomplete.

Complete Table 26.1 by writing, in the right-hand column, the appropriate term to complete each statement.

Table 26.1

event	missing term
Electrons from photosystem I are accepted by an electron acceptor and are passed on to form ..... , required for the light-independent stage.	
Excited electrons leave the ..... of photosystem II and are passed on to an electron transport chain.	
Initially, light energy is absorbed by ..... and the energy absorbed is passed on to cause electrons to be raised to a higher energy level.	
The electrons lost from photosystem II are replaced by electrons from	

[2]

(b) Describe the structure of a guard cell.

You may use the space below for a diagram.

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[Total: 4]

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